Space Weather Technical Forecast

Issued on Saturday, 16 September 2023 at 13:03 Local

This technical forecast provides a four-day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: Large centre-disc filament eruption observed, modelling awaited. G2 Likely late UTC day of Saturday into Sunday. Chance of further G1 Monday. Chance R1 throughout.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity recorded at GOES 16 and 18 has been Moderate in the past 24 hours, with a trio of flares from AR3429 near centre-disc. These flares were successively larger in magnitude, with an M1.7, M2.8 and at 16/0538UTC a peak M3.9. There were up to seven sunspot regions on the disc, with AR3429 by far the most active, although there are now signs of an arriving region in the far east in the form of a unipolar leading spot, as AR3423 becomes less distinct in the far west. The past 24 hours' activity is thought to largely be the work of AR3429's contained Mt Wilson delta spot in its Dai/Beta-Gamma-Delta configuration. This was very mobile in the period with its constituent parts well-formed and essentially orbiting each other at close quarters. Other spots on the disc were largely unremarkable, although the new eastern arrival did produce a C5.0 to perhaps hint at a degree of potential here.

The large filament mentioned in Friday's guidance that previously dominated the central-north disc in H-Alpha, was seen to finally leave the disc in the current UTC morning, perhaps destabilised by the suite of M-class flares from its unruly southern neighbour, AR3429. Imagery of this Coronal Mass Ejection (CME) beyond very close-in Lasco C2 frames is not yet available to ascertain any trajectory, however it appears to be angled significantly westwards and very likely intersecting the ecliptic. There was no significant flare associated, and the emission appears slow, however very tentatively a large CME appears likely to feature late in the current four-day period - to be more fully determined as imagery allows.

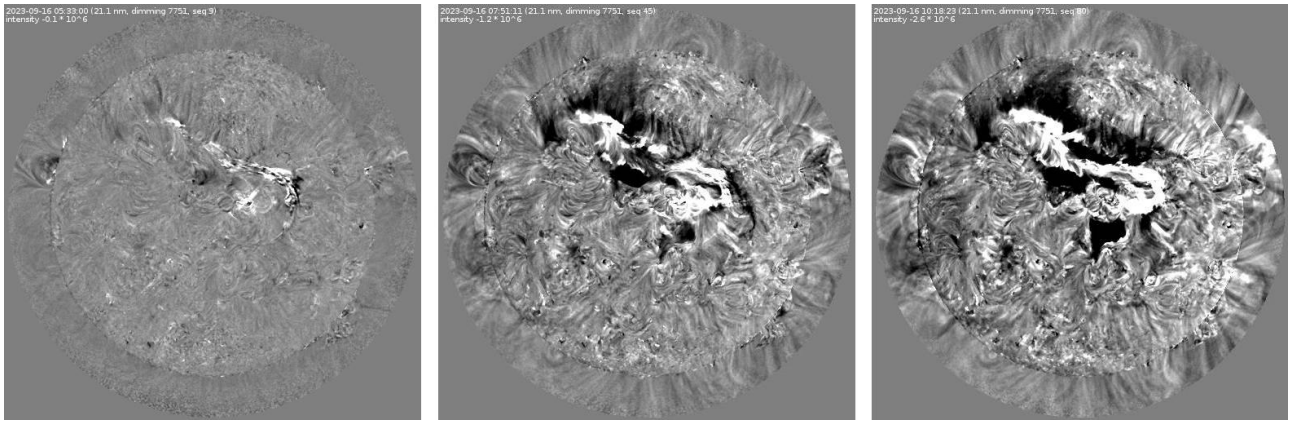

Figure 1: SIDC ROB AIA211 time-integrated dimming of the large centre-disc filament eruption of the current UTC morning. This is now appearing on coronagraph imagery and will be analysed shortly. The ejecta appears to be on and ahead of the Sun-Earth line from early impressions.

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The only other CME visible in coronagraphs in the period was a high-latitude feature apparently heading northeast. There is no obvious front-sided source and this is perhaps far-sided, although full analysis has yet to be conducted. No other CMEs were observed in the past 24 hours.

Solar Wind / Geomagnetic Activity: Solar wind parameters, as measured by DSCOVR (as well as ACE and STEREO A) near L1, are perhaps now thought most likely to be explained as the fast wind from CH47/-, with a possible onset having occurred on Thursday 14 September, but masked by an unusual preceding CIR. This is not a conclusive diagnosis, and there is a small chance of a fast wind arriving within the current UTC day, however this now appears unlikely.

The solar wind speed fell slightly within a solidly negative phi sector (towards the Sun), with the speed falling from around 475 to 425km/s. The solar wind density was level within its typical background scope of single figures ppcc, while the IMF was smooth and steady at or below 6nT. The north-south component was variable but within a typical range of +/-5nT.

The net result of the above solar wind measures was for provisionally Quiet to Unsettled geomagnetic activity, with a peak of Unsettled Kp '3o' in the 09-12UTC interval.

Energetic Particles / Solar Radiation: GOES16 high energy (greater than 10MeV) proton flux was at Background levels.

GOES16 high energy (greater than 2MeV) electron flux was at Normal Background to Moderate levels, with a slightly damped trend relative to the previous 24 hours - below 200pfu at peak. The associated 24-hour fluence was well below the Active threshold, with 3.91e6 integrated pfu observed at 16/0001UTC.

Four-Day Space Weather Forecast Summary

Solar Activity: There is a daily Chance of M-class flares, mainly from AR3429 near centre-disc. The large but fading AR3423 should leave the Earth-facing side over the current UTC weekend, but the flare risk may be maintained by the return of Ex-AR3413 in the east.

Solar Wind / Geomagnetic Activity: The geomagnetic forecast is of lower than average confidence, for a full discussion please see the Geomagnetic Storms section.

The large filament eruption of the current UTC day is awaiting imagery and does not yet feature. Therefore, the main forecast elements are the 14/0745UTC CME (especially), and to a lesser extent the 14/2126UTC CME.

Quiet initial conditions will Likely evolve to G2 Moderate geomagnetic storm within the next 24 hours, receding into the new working week to be replaced by a further Chance of G1 during Monday morning UTC. Conditions provisionally then return to Quiet to round out the period, however, note the filament awaiting analysis may maintain activity.

Energetic Particles / Solar Radiation: High energy (greater than 10 MeV) proton flux is expected to remain at Background levels, with a daily Slight Chance of an enhancement should any larger flares occur.

High energy (greater than 2 MeV) electron flux is likely to be suppressed at Normal Background levels at GEO through much of the period, but perhaps with an eventual increase in the wake of CH47/-, now rendered lower confidence by intervening CMEs. Overall, the 24-hour fluence is Expected to remain below the Active threshold throughout the period, with reducing confidence into the new UTC week.

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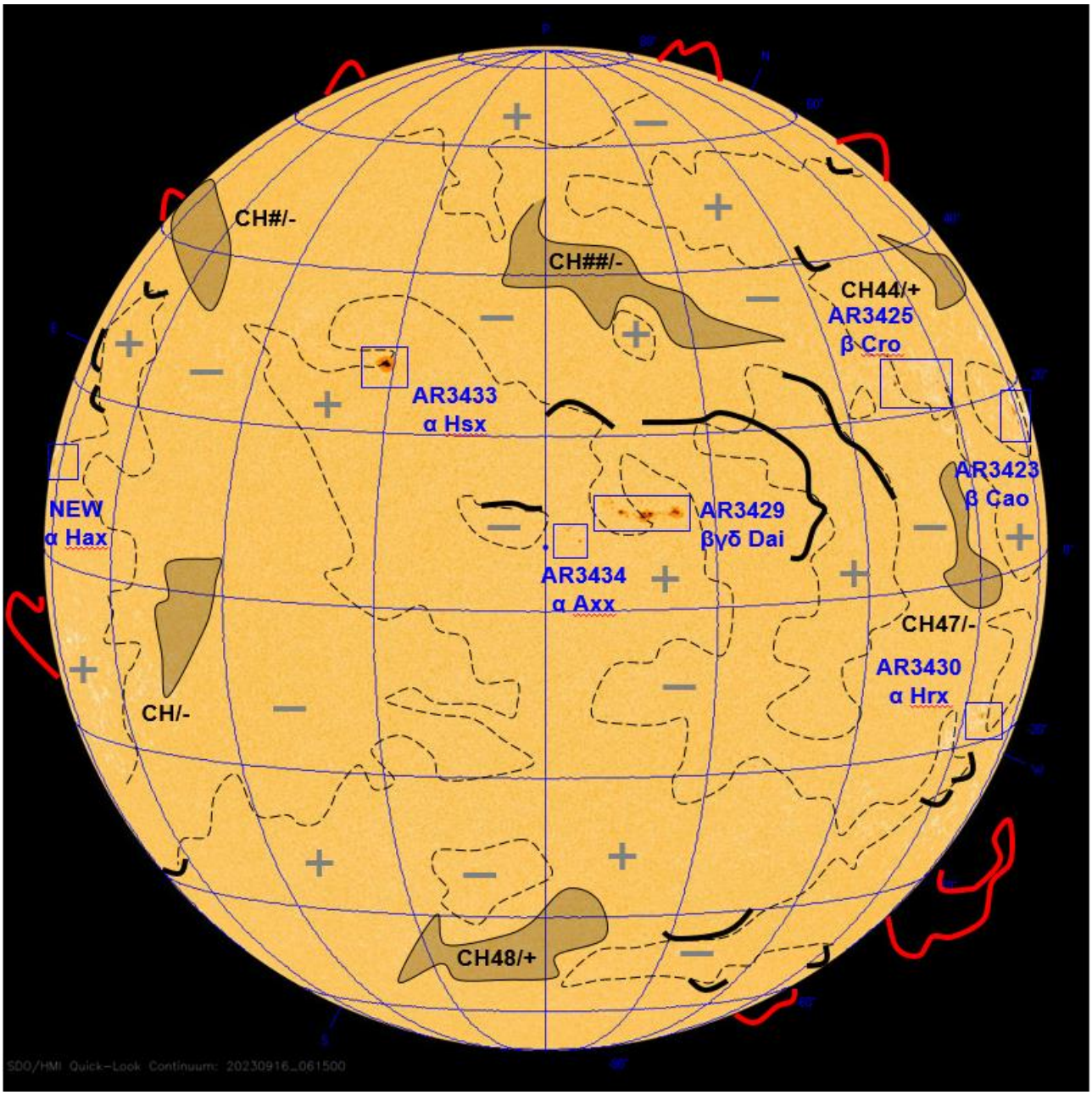
Figure 1. Solar Analysis Valid 16/0615UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

Thinking surrounding current geomagnetic conditions has changed is the past 24 hours. No positive phi angle has been observed recently, and CH44/+'s fast wind is likely to have passed above Earth. This may have contributed slightly to the CIR seen from Thursday 14 September at L1, however this CIR is now considered to perhaps have been the fore-runner into CH47/-. CH47 has therefore perhaps been in progress since - given Slightly Elevated solar winds and a steady negative phi angle. The recently observed solar wind is therefore below persistence and expectations for this feature, which had been thought likely to approach 600km/s. This difference does now mean that MOSWOC Enlil's forecast is perhaps nearer the expected evolution of the solar wind, and confidence in its treatment of CME arrival times is increased.

There are currently two CMEs that feature in the forecast. The large centre-disc filament lift off of the current UTC morning is awaiting imagery for analysis and does not feature. The previously advertised 11 September glancing blow CME is overdue and is now likely to have missed Earth to no effect.

The first and main CME in the forecast was from a large filament eruption in the northwest, associated with an M1.4 flare near AR3423 around 14/0745UTC. This feature was mainly directed north and west of the Sun-Earth line, however a partial halo shock (at least) was observed. The modelled arrival time of this CME was adjusted forwards, to account for what were then seen as Enlil model deficiencies (in the lack of a 600km/s fast wind from CH47/-), however modelling is now considered to be more reflective of current conditions than expected, and an arrival time in the UTC evening of Saturday 16 September is now more likely.

The second CME was likely associated with an M2.4 flare from AR3229 at 14/2126UTC. Although the flare was narrowly in the northeastern quadrant, the CME appears to be directed slightly south and east, with consensus opinion suggesting possible arrival in the UTC morning of Monday 18 September.

All considered, the geomagnetic forecast is of lower than average confidence. The main forecast elements are the 14/0745UTC CME (especially), and to a lesser extent the 14/2126UTC CME. Initially Quiet conditions should give way to a Chance of G2 later in the UTC day of Saturday 16 September, bleeding into Sunday. From here, a further Chance of G1 from the 14/2126UTC CME follows on Monday 18 September. Conditions should then provisionally become Quiet on Tuesday 19 September, however note the recent centre-disc filament lift-off may soon change this.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	60	40	50	10
Strong	G3	No	10	10	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

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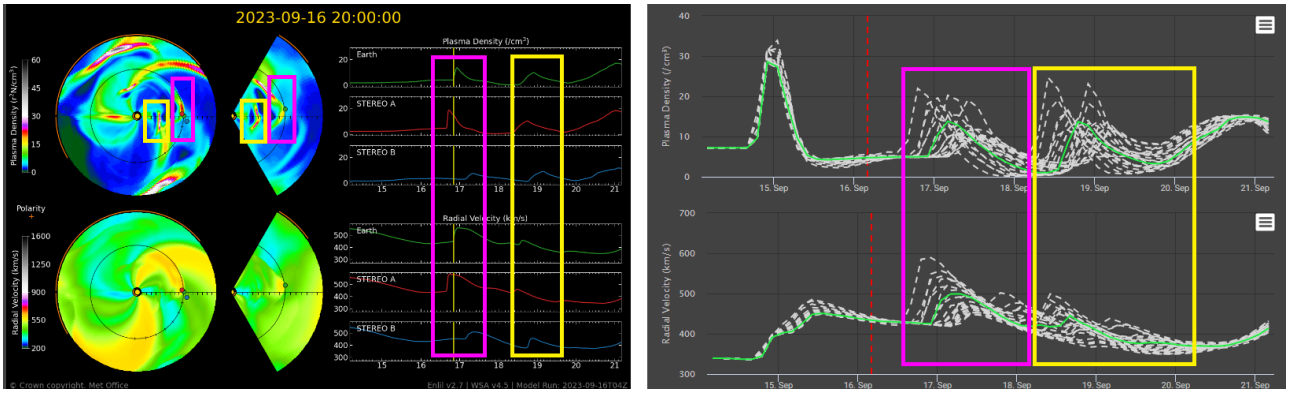
Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
14/1159	Partial	Filament eruption	NW near AR3423	830km/s	UTC evening of 16 Sep	Reasonable chance of hit.
15/0600	Partial	AR3429	M2.4 flare centre-disc	500km/s	18/0900UTC	Edge hit. Low confidence
16/0800-1000UTC	Pending	Filament eruption	Centre-disc	Pending	Pending	Imagery awaited

Figure 2: 16/0400UTC MOSWOC Enlil run showing the two 14 September CMEs' arrival times. Enlil's treatment of expected fast winds in the period is now felt to be more representative, and earlier corrections to arrival times are not felt necessary – the coming UTC evening for the G2 CME and Monday morning UTC for the G1. Note that this run does not include the recent centre-disc filament eruption.



Radio Blackouts - X-Ray Flares:

Current X-ray activity is heavily tied to the fortunes of the Mt Wilson delta spot contained within centre-disc AR3429. The constituent parts of this delta are currently very mobile and appear to be in orbit of each other in the past 24 hours. The evolution from here is uncertain - they could now separate or else continue their interaction, however given the current state of affairs the X-ray risks are felt to have to rise above raw values. The rationale for this being that the raw values only account for Zurich classes, and the activity is more likely down to features not captured by this system (i.e. mobility, growth and the delta itself).

In terms of the forecast, AR3423 is expected to rotate off the visible disc over the UTC weekend, however a large region is expected to rotate over the eastern horizon to mitigate against any otherwise declining risk. This arriving region is expected to be the returning Ex-AR3413, which was responsible for numerous M-class flares during when last on the visible disc. This group may now be emerging on the far eastern solar horizon, however as yet its leading spot is the only part visible, and the current UTC morning's C5.0 is perhaps an underestimate of its capability.

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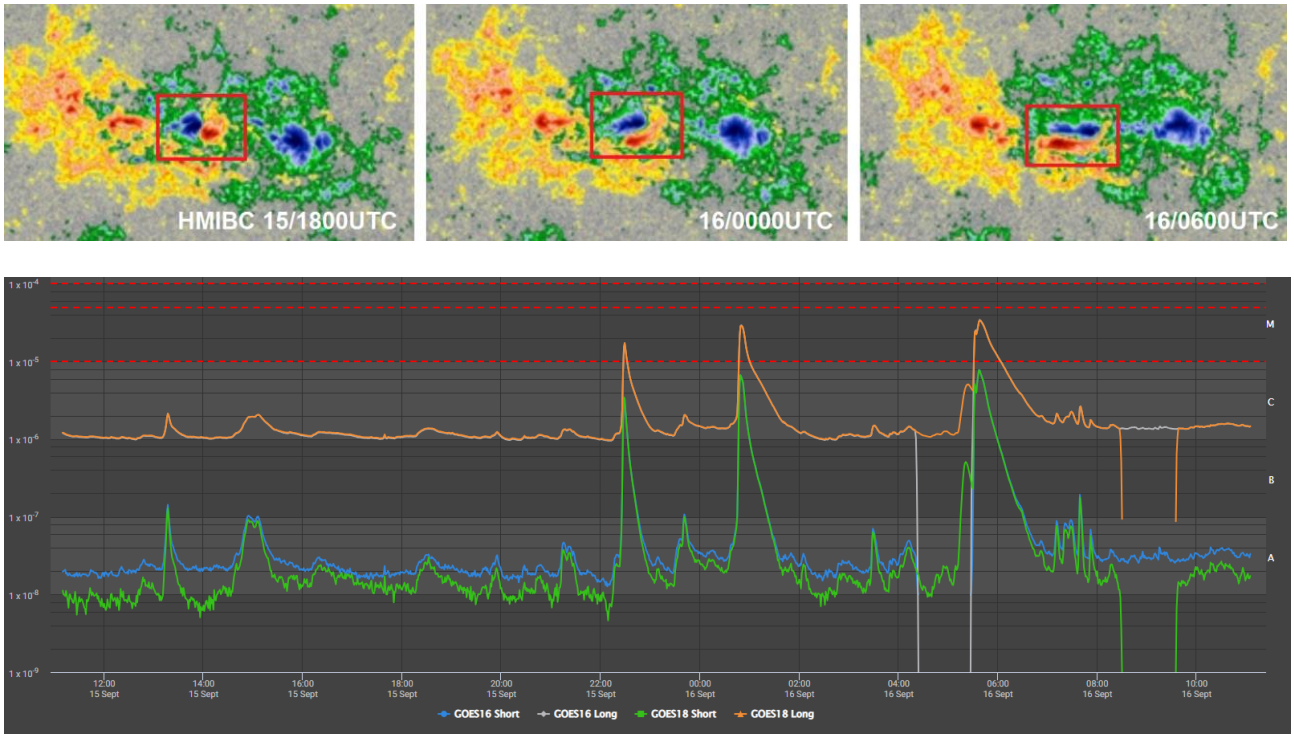
X Ray Flares Probability	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	R1-R2 M Class	Yes	50	50	50	50
Very Active	R3 to R5 X Class	No	10	10	10	10

Figure 3: HMIBC sequence of movement in the central delta spot in AR3429 in the UTC overnight period. Resulting X-ray flares in GOES16 and 18 can be seen below.



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Solar Radiation Storms - (High Energy Protons):

The high energy (greater than 10MeV) proton flux observed by GOES16 is expected to persist at Background levels. There remains a daily Slight Chance of flux levels rising in response to any significant flaring, with the risk raised a little relative to raw values as these are based on Zurich classes and most activity is felt to be due to the Mt Wilson delta in AR3429 at present. The focus is now also gradually moving from AR3423 (currently near the western limb) to central AR3429.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	10	10	10	10
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

High Energy Electrons Event (≥ 2MeV):

High energy (greater than 2MeV) electron flux levels are currently at Normal Background levels. Thoughts are now changing as to the likely state of upcoming fast wind streams, perhaps most specifically that CH44/+ has very likely missed, and CH47/- may already be in course - this despite the slightly unusual observation that the solar wind speed decreased slightly in the wake of the CIR.

This unfortunately lowers confidence in forecast electron populations at GEO still further, although the net result is perhaps inconsequential as Active fluence is probably less likely. The rationale for this is that there is now a significant departure from the Strong fast wind from CH47's predecessor, with 450-500km/s instead observed, and even this is now waning. While a degree of recovery is now expected in electron populations, perhaps within the current UTC day, the expected arrival of CMEs in the coming days should repeatedly impede recovery and perhaps redistribute any limited gains from CH47 - if it is already present.

The overall forecast is therefore a Slight Chance on all days, rising slightly as the risk of CMEs fades.

GEO Electron Environment Probability (Exceedance)	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ 2 MeV ≥ $1x10^8$**	No	1	1	5	10
Very Active	**≥ 2 MeV ≥ $1x10^9$**	No	1	1	1	1

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